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Fatal Car Fires from Rear-End Crashes: The Effects of Fuel Tank Placement before and after Regulation

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ABSTRACT

A federal standard for fuel tank integrity in cars was applied to 1977 and subsequent models. National data indicate that fatalities per 10 000 occupants in rear-end crashes of small cars, where fire was the most harmful event, were reduced by approximately 57% if the fuel tank was located behind the rear axle and 77% if the tank was situated directly above or in front of the rear axle. (*Am J Public Health.* 1993;83:1168–1170)

Introduction

In a rear-end crash, the fuel tank of a car, if located in the usual crush zone, may be ruptured at moderate speed if it is penetrated by other vehicle components. In 1973, the Insurance Institute for Highway Safety examined the integrity of fuel systems in six 1973-model cars by conducting front-to-rear crash tests at speeds of 36 to 40 miles per hour with the struck car sitting still. Fuel leaked from the tank of the struck car in every case, and a spontaneous fire occurred in one test. Slow motion film of the latter crash indicated that the fire enveloped the passenger compartment of the struck car before the vehicles came to rest but after the momentum of the crash was dissipated.[1]

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As a result of pressure from Congress, the National Highway Traffic Safety Administration issued standards for fuel system integrity that became applicable to 1977 and subsequent model cars sold in the United States. The standard required minimum fuel leakage in moving barrier and rollover crash tests. The means of compliance were left to the manufacturers.

In some models, the manufacturers placed the fuel tank directly above or in front of the rear axle; in other models, they were able to meet the minimum standard by alternative means while leaving the tank behind the rear axle. This study compared cars with fuel tanks behind the rear axle and those with fuel tanks directly above or in front of the rear axle to determine the risk of fatal fire to vehicle occupants in rear crashes. Cars manufactured both before and after the federal standard were included, controlling for vehicle size. In most of the latter cases, the tank was located in front of the axle.

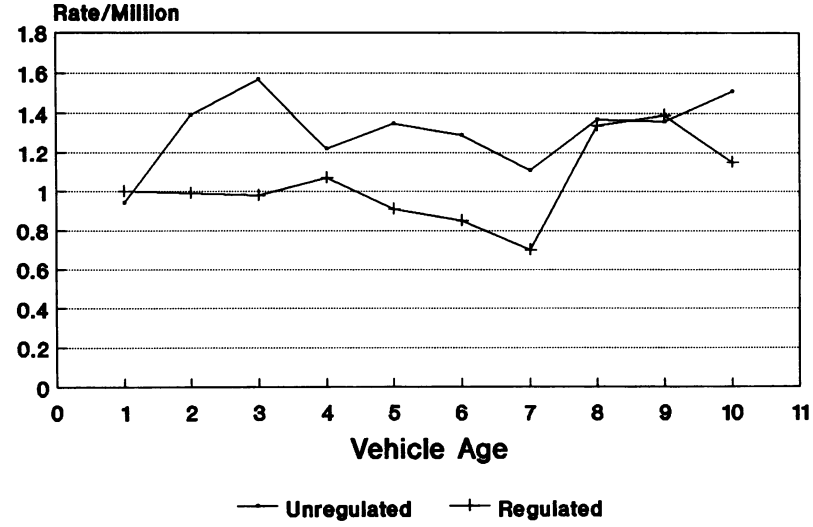

FIGURE 1—Rate of fire crashes per million cars in use by age and regulation: United States, 1977 through 1989.

Methods

Data on fire-related fatalities in rear-end collisions during 1977 through 1989 were obtained from the computer files of the Fatal Accident Reporting System. This system collects data on virtually all crashes on US public roads in which a person involved dies within 30 days. Vehicles in use by age were obtained from a published source.[2] Rear-fire crash rates per cars in use were calculated by age and regulation.

A sample of cars in used car lots was inspected for fuel tank placement and identified by make, model, and model year to assess the effect of tank placement. These data were augmented by an unpublished Ford Motor Company study of tank placement in its vehicles and those of other manufacturers. (A list of the cars included in the study is available from the author.)

Exposure of occupants of the identified cars in rear-end crashes was estimated from the National Accident Sampling System.[3] Data on police-reported crashes in a representative sample of the United States are included in this system. Data identifying cars struck in the rear and number of occupants during the calendar years 1981 through 1986 were obtained from the above-mentioned computer tapes. Since the National Accident Sampling System was revised in 1987, data for that and subsequent years were not used in the occupant-exposure phase of the study.

The national estimate of number of occupants in a given model's rear crashes was obtained from the sum of the inverses of the sampling ratios for each case. The number of fire-related deaths per 10 000 occupants in rear-end crashes was calculated and compared by placement of fuel tank, vehicle size, and model year (pre-1977 or post-1977) separately for all fires and for fire as the "most harmful event" (the event that resulted in the most damage to the vehicle or the occupants). Vehicle size was indicated by wheelbase (the distance in inches from the front to rear axle[4,5]), which is a substantial predictor of fatal crash rates.[6]

TABLE 1—Fire-Related Deaths in Rear Crashes, by Fuel Tank Placement, Model Year, and Vehicle Size: 1981 through 1986

Location of Fuel Tank/Model Year	Wheelbase, in	No. of Fire Deaths	Fire Most Harmful Event	Estimated No. of Occupants	Rate Estimates: NASS Sample Size	Rate Estimates: No. of Deaths[a]	Rate Estimates: Fire Most Harmful Event[a]
Behind rear axle							
Pre-1977	<100.1	79	42	55 247	188	10.5	5.6
	100.1–110	76	32	131 455	403	5.8	2.4
	110.1–120	55	33	304 236	890	1.8	1.1
	120+	46	20	294 952	815	1.6	0.7
Post-1977	<100.1	68	30	127 281	444	5.3	2.4
	100.1–110	84	55	262 198	897	3.2	2.1
	110.1–120	69	29	292 139	1004	2.4	1.0
	120+	3	1	22 521	83	1.3	0.4
Directly above or in front of rear axle							
Pre-1977	<100.1	24	12	49 569	158	4.8	2.4
	100.1–110	0	0	8 048	25	0.0	0.0
	110.1–120	0	0	190	2	0.0	0.0
Post-1977	<100.1	52	27	204 074	716	2.5	1.3
	100.1–110	31	12	152 760	600	2.0	0.8
	110.1–120	0	0	8 933	30	0.0	0.0
	120+	0	0	4 942	20	0.0	0.0

Note. The data exclude 30% of deaths in which tank placement was unknown. NASS = National Accident Sampling System.
[a]Per 10 000 occupants

Results

The fatal rear-end fire crash rate per million cars in use by age of vehicle is

TABLE 2—Weighted Least Squares Regression of Number of Deaths per 10 000 Occupants

	Coefficient	*t*
Fire most harmful event		
Intercept	3.82	
Tank placement[a]	−1.15	−4.46
Wheelbase[b]	−0.81	−6.75
Regulation[c]	−0.36	−1.73
R^2 = 0.81		
All fatal fire-related crashes		
Intercept	6.73	
Tank placement[a]	−1.86	−2.77
Wheelbase[b]	−4.33	−4.33
Regulation[c]	−0.45	−0.84
R^2 = .66		

Note. Weight was calculated by the following formula: National Accident Sampling System sample size/($p \times (1 - p)$, where p is the proportion of occupants that died as a result of crashes. The critical *t* value (two-tailed test, $P = .05$) was = −2.15.
[a]1 = directly above or in front of rear axle, 0 = behind rear axle.
[b]1 = less than 100.1 in, 4 = 120 or more in.
[c]1 = post-1977, 0 = pre-1977.

displayed in Figure 1. With the exception of cars 1, 9, and 10 years old, the regulated vehicles had consistently lower rates. Vehicle age was unrelated to the overall death rate independent of regulation.

The numbers of fire-related deaths and estimated occupants in rear crashes during 1981 through 1986 are presented in Table 1, along with the National Accident Sampling System estimates of number of occupants and death rates per 10 000 occupants. The fire-related death rate is strongly related to tank placement and wheelbase.

Among smaller cars, the regulated 1977 and subsequent models have lower death rates than those manufactured before 1977, particularly those in which the fuel tank was situated in front of the rear axle. In cars with wheelbases of 100 in or less, the 1977 and subsequent models with fuel tanks located behind the rear axle had a most-harmful-event death rate 57% lower than the earlier models, and those with tanks located directly above or in front of the rear axle had a rate 77% lower.

A weighted regression analysis is presented in Table 2. Tank placement and wheelbase were the main contributors to the variance explained.

Discussion

These data indicate that fuel tank placement had a substantial effect on the reduction of fire-related death rates to occupants of cars struck in the rear, particularly among smaller cars. Apparently, fire-related deaths would have increased substantially as vehicles were "downsized" had there been no change in vehicle design. The placement of tanks directly above or in front of the rear axle apparently reduced fire-related deaths by more than half in 1977 and subsequent models and greatly reduced vehicle-size differences. The extent to which change in vehicle design is attributable solely to regulation, as opposed to adverse publicity, lawsuits, and general attention to the problem, is known only by the manufacturers. □

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